 by Pete Avitabile

Illustration by Mike Avitabile

Double impacts are undesirable. What about multiple impacts?
Ahhh… Now this is something that we have to discuss.

We have discussed double impacts before and have shown that while they are undesirable, they may be unavoidable in many cases. In fact, previously we showed that the double impact measurement wasn't necessarily as bad as most people profess. Of course, the overall measurement, including the frequency response and the coherence, must be checked along with the averaged spectrums for the measurement.

Now the question here is really if multiple impacts can be used as an excitation technique and if there is any problem using a measurement made from multiple impacts.

This is actually a very good question and needs to be thought through carefully. An impact measurement typically is the result of a single impact; the response due to that impact is generally a damped exponentially decaying response.

Now if we were to consider an arbitrary input force, then that signal can be thought of as a series of impulses added together spaced delta t seconds apart in order to characterize the input. In fact, this is the way that arbitrary signals are handled in any vibrations text book – the solution method is called the superposition method, or convolution integral, or Duhamel's integral – and is used to compute arbitrary response of any system.

In this case, the series of pulses will be applied to the structure. But some care needs to be used here. The impulses should be applied in a very incoherent fashion in terms of their timing and spacing. The pulses should also not be applied for the entire sample period. They should be applied for a portion of the sample interval, 50% to 75% for instance. But it is also important for the response to be totally observed within the sample interval so that no leakage will occur.

In this way, all the requirements of the Fourier transform are satisfied. In fact, the signal will start to approach a broad band excitation with characteristics similar to that of a random signal like a burst random.

A simple structure is used to illustrate the technique. Due to the responsive nature of the structure, double impact measurements are unavoidable but they are not serious enough so as to corrupt the measurement overall.

In the first case, a single impact measurement is applied – or least the intent is to apply a single impact. Figure 1 shows the time signals for the impact and response. Figure 2 shows the input power spectrum with the frequency response. Figure 3 shows the frequency response function along with the coherence. Overall the measurement is good but the effects of double impact are seen in the input time excitation and the input spectrum noted by a varying input spectrum. The variation of the input spectrum is small enough so as to not distort the overall measurement for the system as evidenced by the coherence.

In the second case, a series of impact measurements were applied to the structure. Figure 4 shows the time signals for the impact and response. Figure 5 shows the input power spectrum with the frequency response. Figure 6 shows the frequency response function along with the coherence. While multiple impacts were applied, the overall measurement is very good. The resulting frequency response and coherence are very good.

I hope that this shows that multiple impact excitations can in fact be used to excite the structure and measure good overall response functions. If you have any more questions on modal analysis, just ask me.

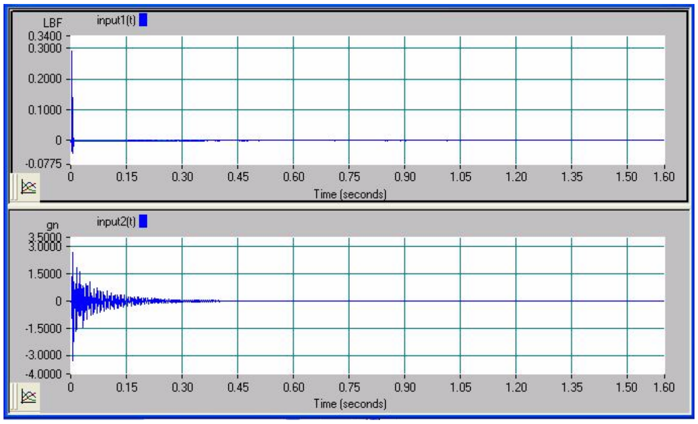

Figure 1 – Excitation (top) and Response (bottom)
with Single Impact Excitation for Case 1

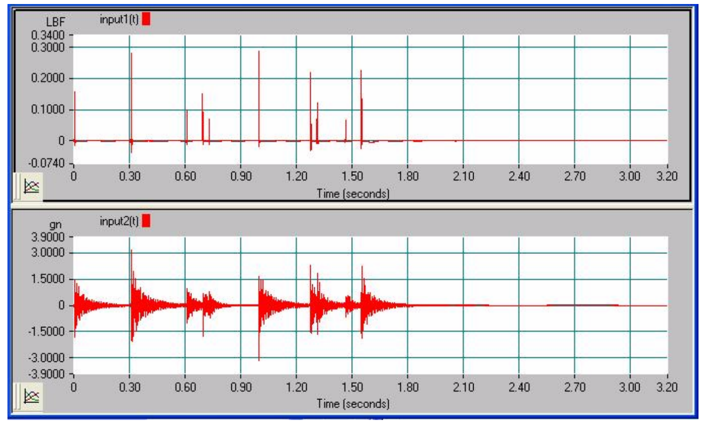

Figure 4 – Excitation (top) and Response (bottom)
with Multiple Impact Excitation for Case 2

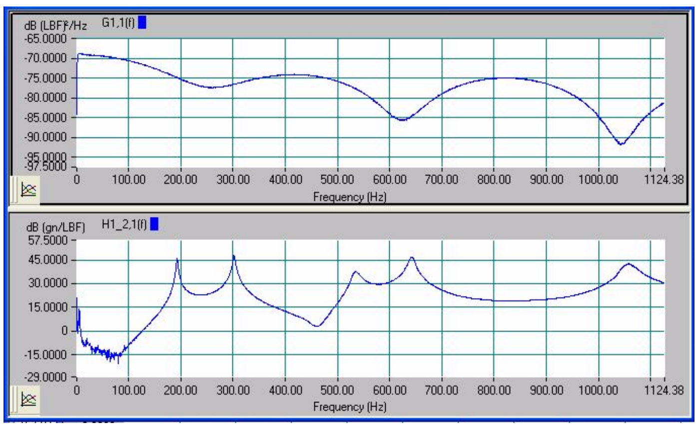

Figure 2 – FRF (bottom) & Input Power (top)
with Single Impact Excitation for Case 1

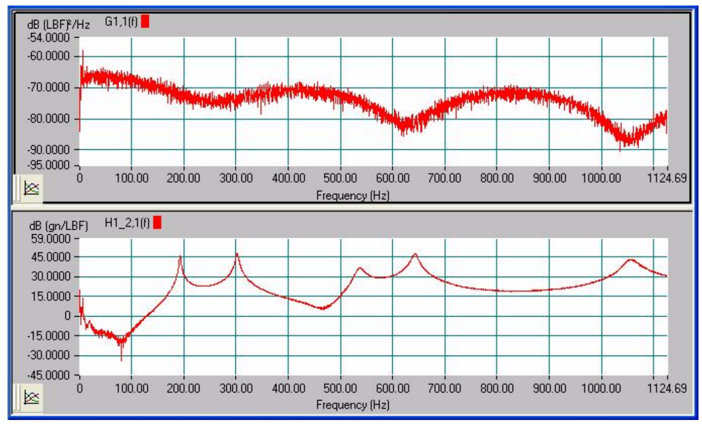

Figure 5 – FRF (bottom) & Input Power (top)
with Multiple Impact Excitation for Case 2

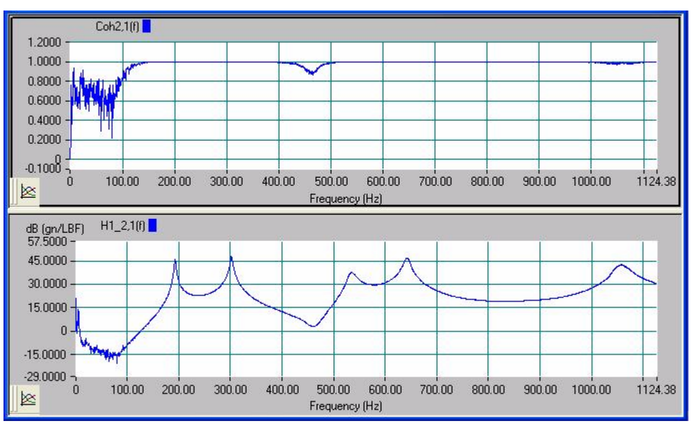

Figure 2 – FRF (bottom) & Coherence (top)
with Single Impact Excitation for Case 1

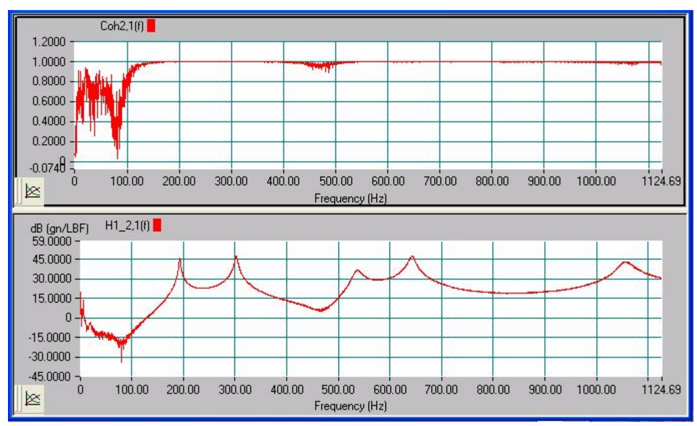

Figure 6 – FRF (bottom) & Coherence (top)
with Multiple Impact Excitation for Case 2